Cognitive issues of mobile map design and use: A collaborative research agenda

Griffin, Amy L ; Reichenbacher, Tumasch ; Liao, Hua ; Wang, Wangshu ; Cao, Yinghui

DOI: https://doi.org/10.5194/ica-abs-6-79-2023

International Cartographic Association
Association Cartographique Internationale

Cognitive issues of mobile map design and use: A collaborative research agenda

Amy L. Griffin [a,*], Tumasch Reichenbacher [b], Hua Liao [c], Wangshu Wang [d], Yinghui Cao [e]

[a] *RMIT University – amy.griffin@rmit.edu.au*
[b] *University of Zürich – tumasch.reichenbacher@geo.uzh.ch*
[c] *Hunan Normal University – liaohua@mail.bnu.edu.cn*
[d] *TU Wien – wangshu.wang@geo.tuwien.ac.at*
[e] *Qingdao University – yinghui.cathy@gmail.com*

* Corresponding author

Keywords: mobile map, cognition, cognitive load, context

Abstract:

Mobile telecommunications devices have made their way into the hands of most of the world's population in the almost fifty years since the world's first mass-produced mobile phone was put on the market by Motorola in 1973 (Farley 2005, Radicati 2021). Like other information sources, maps have also benefited from and been re-envisioned for internet-connected mobile devices. We can now use maps to support our everyday activities in ways that were unimaginable with paper maps – for example, providing real-time updates and design that adapts when their use context changes. However, these new use contexts also often generate additional cognitive load, by presenting distractions in noisy and highly dynamic environments. This increased cognitive load is exacerbated by the design constraints posed by the characteristics that make mobile devices portable (e.g., small screens). To mitigate this increased cognitive load from mobile map use cases, there are at least two options: reduce the cognitive load by externalizing cognition and/or distribute cognition among other actors (machines or people). While some foundational work exists (e.g., Reichenbacher 2004, Meng et al. 2005, Thrash et al. 2019), there are many dimensions of how people use mobile maps and how we can best design such maps that are un- or under-explored.

In this abstract, we present a subset of our research agenda paper for understanding cognitive issues of mobile map design and use published in a special issue of the *Journal of Location Based Services* on user experience design for mobile cartography (see Griffin et al. forthcoming). It explores recent literature relevant to understanding how cognitive processes shape the successful use of mobile maps. In the review, we examine two strategies designers could use to mitigate high cognitive loads associated with mobile map use: offloading cognition by externalizing it and/or distributing cognition among other actors such machines or people. We explore these strategies in depth and identify knowledge that is missing to implement them effectively when designing mobile maps. To do this, we consider their relevance to several mobile map use cases (navigation, individual spatial decision making, collaborative spatial decision making, information enrichment, and entertainment). Next, we identify methodological innovations that are needed to better understand cognitive processes in mobile map use situations. Finally, we explore individual and social impacts of mobile maps and how they are entangled with cognition. For example, we explore the privacy concerns that might arise from capturing physiological measurements that indicate cognitive load, and we consider the long-term impacts of mobile map use on users' cognitive abilities. In the presentation, we will discuss the larger set of opportunities we identified and their relationship to the other contributions (Huang et al., under review; Roth et al., under review).

From the opportunities we identified in our review, we highlight two important cross-cutting research questions:

1. How can mobile maps be designed to reduce cognitive load by providing what is really needed by users to facilitate their cognitive processes? (Opportunities 1.1, 1.2)

    a) What is the right amount of information that needs to be provided? (Opp. 3.2, 4.2, 7.1, 8.1)
    b) What is the right level of assistance from people or machines? (Opp. 3.1, 4.1, 8.2, 14.4)
    c) When should that assistance be provided? (Opp. 9.2)
    d) How much awareness of this assistance is needed by the user? (Opp. 3.3)

2. How can the intrinsic cognitive load created by mobile maps be managed and minimized by supporting the attention distribution between the map and environment (Opp. 2.1, 2.2, 6.2)?

Abstracts of the International Cartographic Association, 6, 79, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-79-2023 | © Author(s) 2023. CC BY 4.0 License.

In Table 1, we present the research opportunities associated with these cross-cutting questions (question 1, yellow shading; question 2, green shading), a subset of those discussed in the research agenda paper.

1.1	With what methodologies and devices can we best measure the cognitive load related to mobile map use?
1.2	How much do we need to understand about the source of the cognitive load (intrinsic, extrinsic, germane) to determine how mobile maps can be designed to minimize cognitive load?
3.2	How do we decide how much context should be shared between humans and machines for mobile map use?
4.2	How do we decide how much context should be shared for collaborative mobile map use tasks?
7.1	How much explanatory information needs to be provided by mobile-map-based SDSS to satisfy users' needs for understanding and trusting the simplified decision options the machine proposes?
8.1	What is a good method to communicate context to facilitate collaborative decision-making with mobile maps?
3.1	How many and which tasks can and should be distributed between humans and machines, i.e., which tasks profit most?
4.1	What are the important social cues for collaborative mobile map use?
8.2	How can we identify communication and coordination requirements for different applications of mobile map-based collaborative spatial decision support?
14.4	What are the ethical implications (e.g., who is in control of an automated process) of distributing cognition between mobile map users and machines and of allowing decision-making by machines?
9.2	What information should an automated map service push to which mobile map users, and in what form, where and when should it be pushed?
3.3	How can we clearly communicate to the user what the machine is doing when we outsource cognitive processing to a machine?
2.1	How much attention needs to be focused on the environment versus the map for successful mobile map use?
2.2	What design elements support a mobile map user's ability to effectively distribute attention between the map and the wider environment?
6.2	How is the map user's attention distributed differently when the mobile map offers different kinds of support for understanding the relationship between the map user and the environment?

Table 1: Research opportunities for answering cross-cutting questions, adapted from Griffin et al. (under review).

References:

Farley, T. 2005. Mobile telephone history. Telektronikk 101, 3/4: 22-34.

Griffin, A. L., T. Reichenbacher, H. Liao, W. Wang, and Y. Cao. under review. Cognitive issues of mobile map design and use. Journal of Location Based Services.

Huang, H., Y. Cheng, W. Dong, G. Gartner, J. Krisp, and L. Meng. under review. Data modeling and processing in location based services: Research challenges and opportunities. Journal of Location Based Services.

Meng, L., Zipf, A., and Reichenbacher, T. 2005. Map-based Mobile Services: Theories, Methods, and Implementations. Berlin: Springer.

Radicati. 2021. Mobile Statistics Report, 2021-2025, available at: https://www.radicati.com/wp/wp-content/uploads/2021/Mobile_ Statistics_Report,_2021-2025_Executive_Summary.pdf.

Reichenbacher, T. 2004. Mobile Cartography - Adaptive Visualisation of Geographic Information on Mobile Devices. PhD Thesis. Technical University of Munich, Munich, Germany.

Roth, R. E., A. Çöltekin, L. Delazari, B. Denney, A. Mendonça, J. Shen, Z. Stachoň, and M. Wu. forthcoming. Making maps & visualizations for mobile devices: Challenges for mobile-first and responsive cartographic design. Journal of Location Based Services.

Thrash, T., Lanini-Maggi, S., Fabrikant, S.I., Bertel, S., Brügger, A., Credé, S., Do, C.T., Gartner, G., Huang, H., Münzer, S., and K.-F. Richter. (2019). The future of geographic information displays from GIScience, cartographic, and cognitive

science perspectives (vision paper). 14th International Conference on Spatial Information Theory (COSIT 2019), 142, 19: 1-19:11.

Abstracts of the International Cartographic Association, 6, 79, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-79-2023 | © Author(s) 2023. CC BY 4.0 License.